Nitrate Contamination in the Sumas-Blaine Aquifer—Sibling to Lower Yakima

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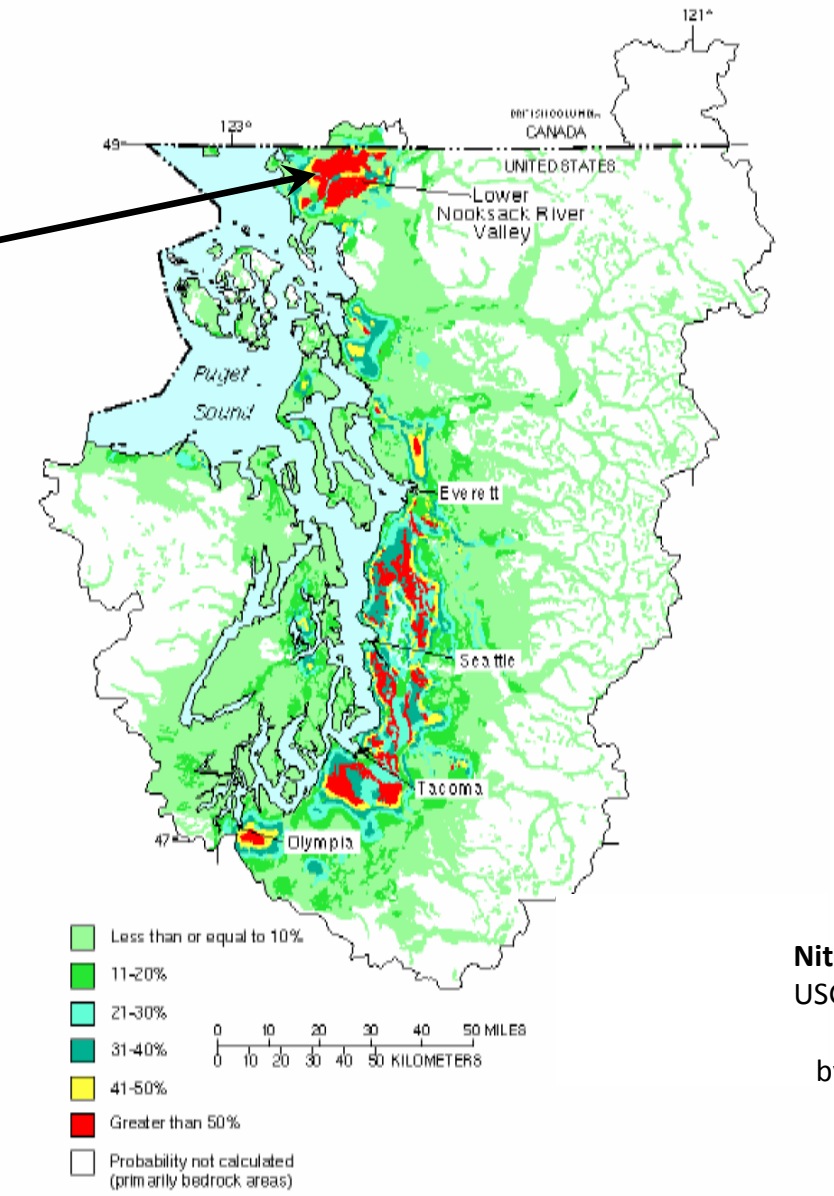
WASHINGTON STATE DEPARTMENT OF ECOLOGY

Where is the Sumas-Blaine Aquifer?



Vulnerability map. Probability (in percent) of detecting nitrate at concentrations of 3 milligrams per liter or greater in wells that are 50 feet deep in the Puget Sound Basin. USGS FS-061-97

Nitrate Vulnerability Map
USGS Fact Sheet FS-061-97

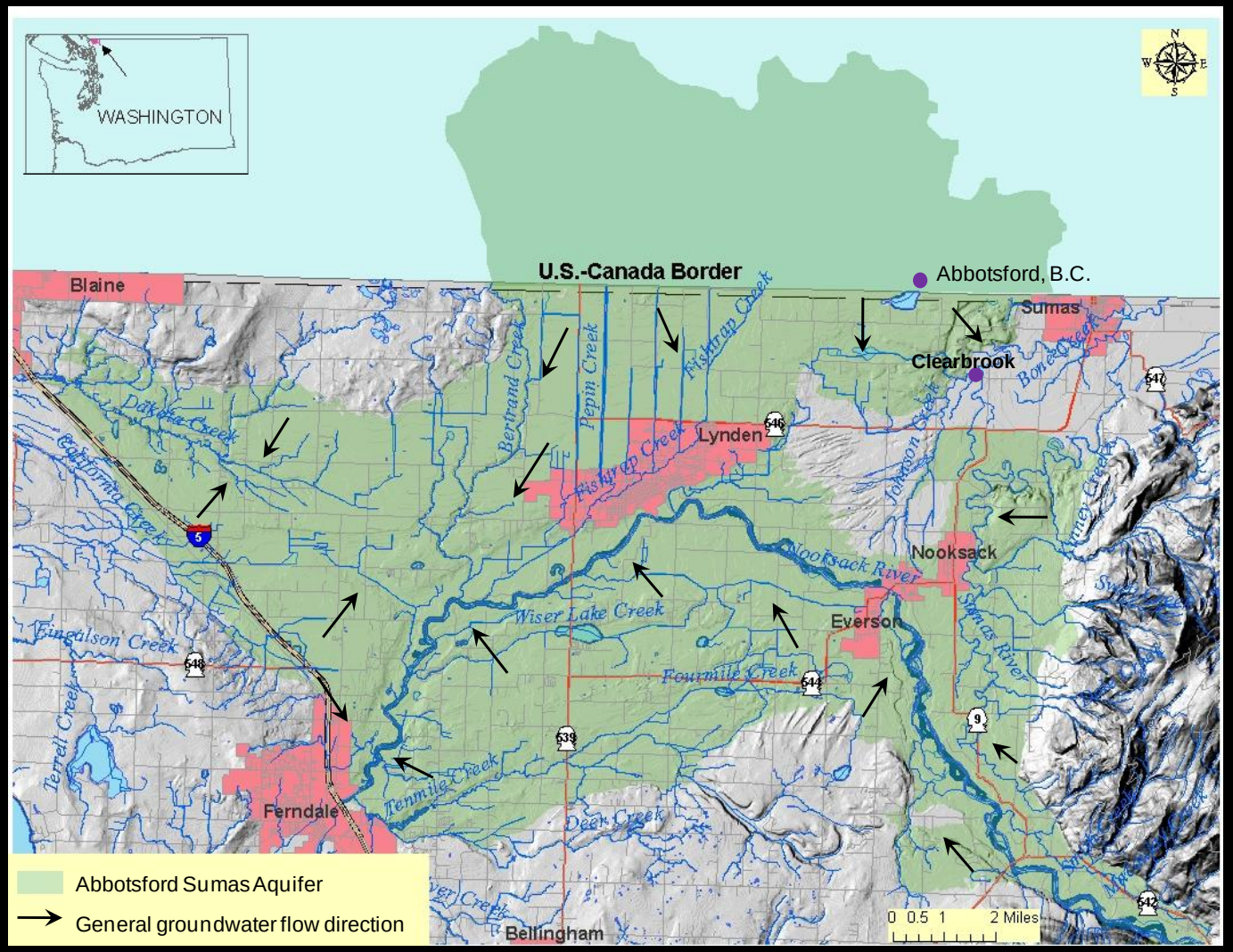
by M.L. Erwin and A.J.Tesoriero
June 1997

Nitrate contamination in the Sumas-Blaine Aquifer

- Why do we care?
- How bad is it?
- What makes the aquifer so vulnerable?
- What are the **sources** of nitrate?
- What **practices** contribute to the problem?
- How does it compare with Lower Yakima?

Sumas-Blaine Aquifer—Why do we care?

- Drinking water for 18-27,000 people (sole source)
- Elevated GW nitrate since 1970's
- Intensive Ag:
  - Dairies
  - Berries
- 6 public water supplies can't use water (1,200 people)

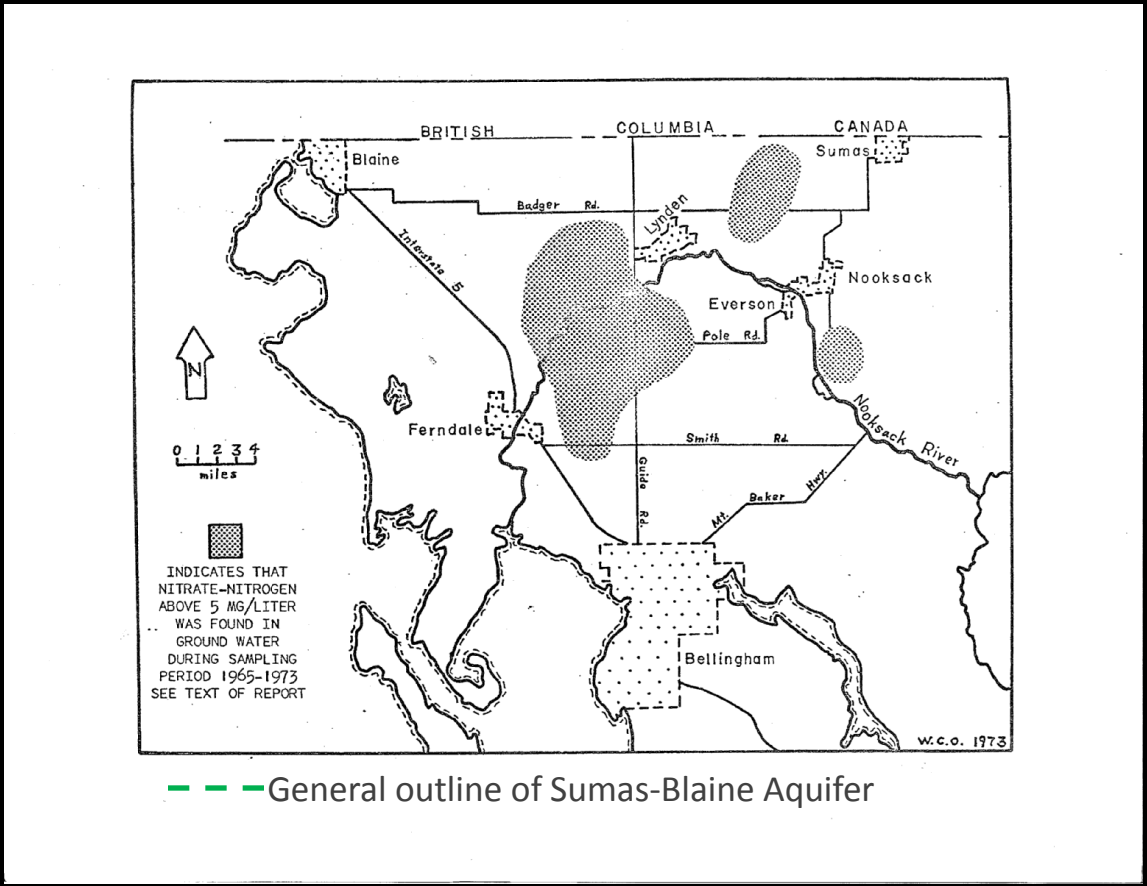


(Aquifer boundaries from Tooley and Erickson, 2006; Graham, 2010)

Historical perspective

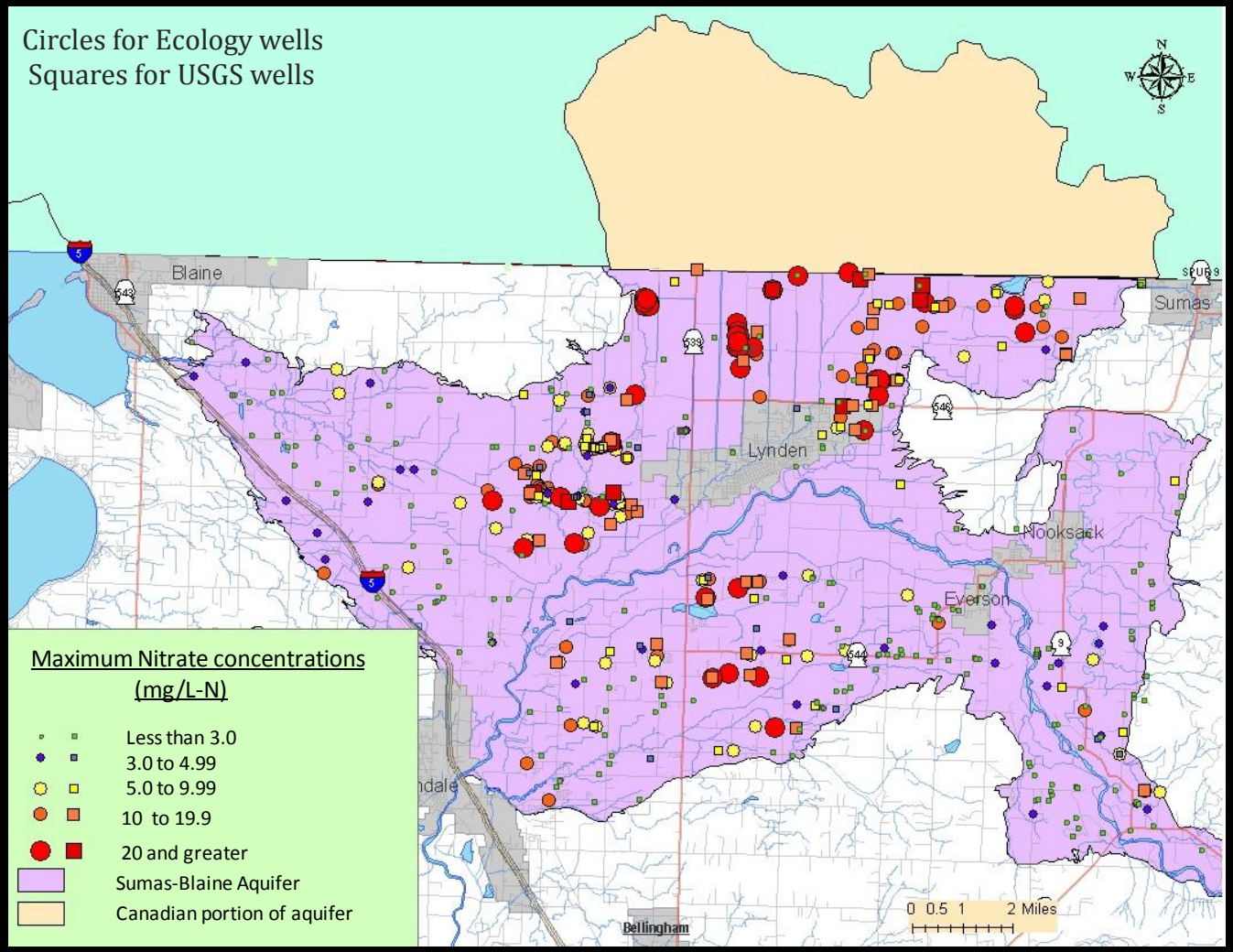
1965-72
82 wells
sampled

- 12% > 10 mg/L nitrate-N
- (MCL=10 mg/L-N)
- 27% ≥ 5 mg/L-N
- 1% >≥ 20 mg/L-N



(from Obert, 1973)

How bad is it?



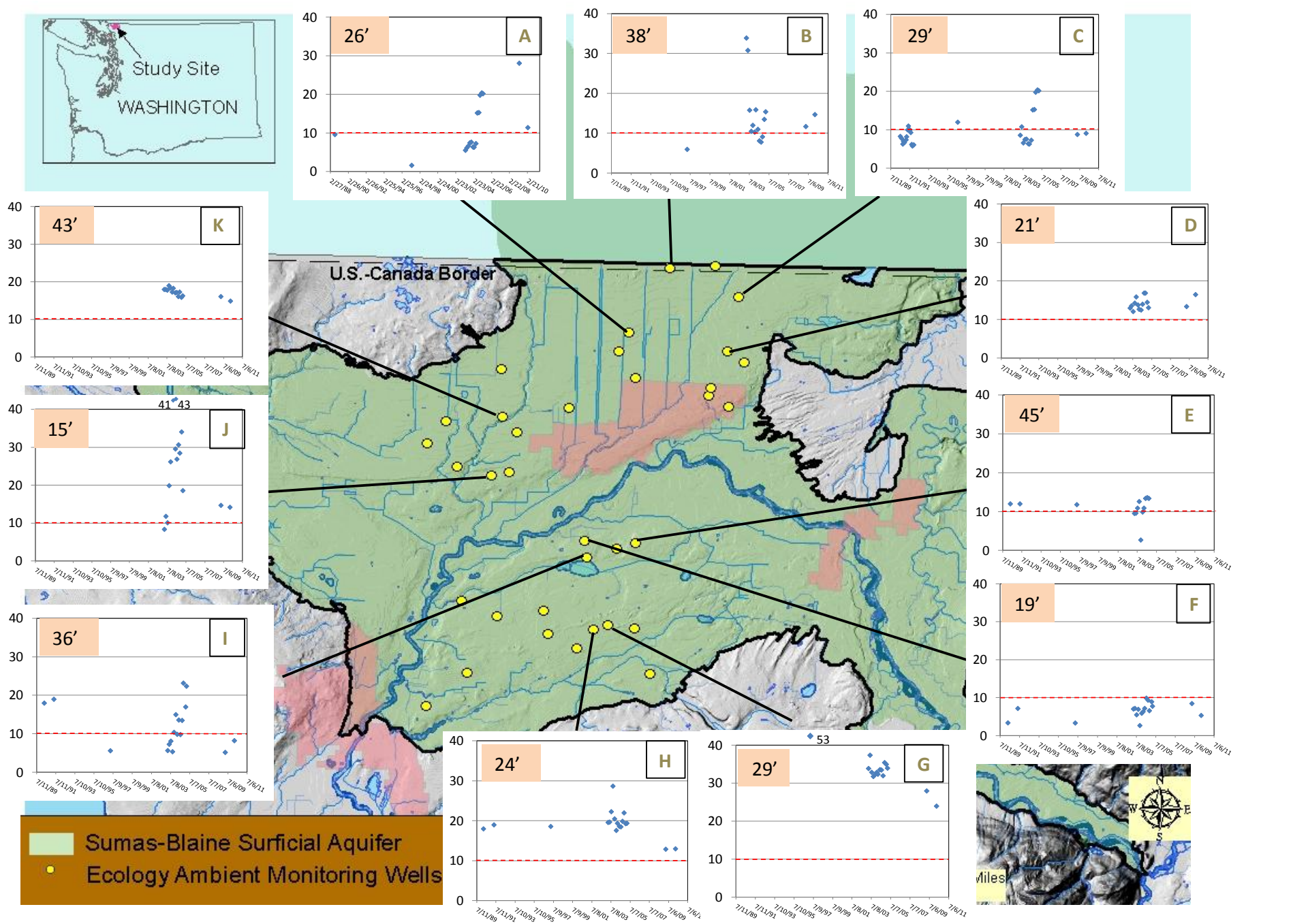
515 wells sampled by Ecology and USGS (1981-2010):

Nitrate –N concentrations:

- 29% ≥10 mg/L
- 44% ≥ 5 mg/L
- 14% ≥ 20 mg/L

- 73 mg/L max nitrate-N in private well

Wells over 10 mg/L > doubled since196'0's-70's.



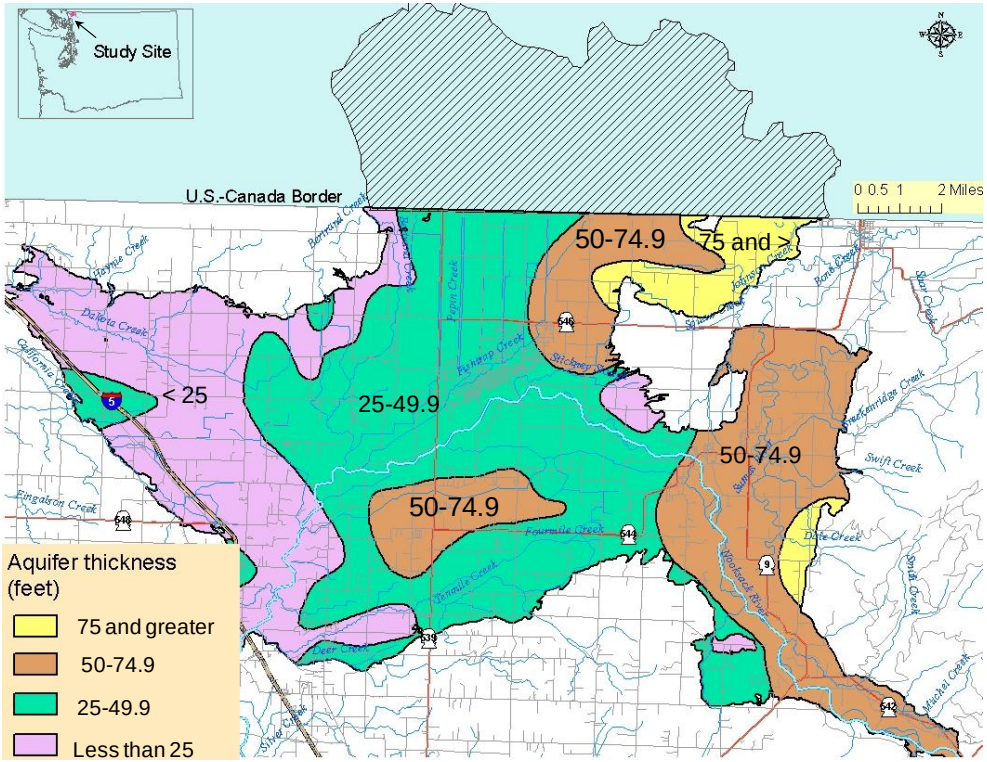
Long-term nitrate-N records in selected wells (1981-2010).

Long-term record

- Most wells consistently >10 mg/L nitrate-N
- Nitrate > 10 throughout the aquifer, esp. central area
- Seasonal variability in some wells
- No obvious sign of improvement
- Many variables affecting any one point
  - Precipitation (dilution)
  - Land use activities upgradient (varies annually)
  - Weather—affects crop uptake

What are the physical factors that contribute to the Sumas-Blaine Aquifer's vulnerability?

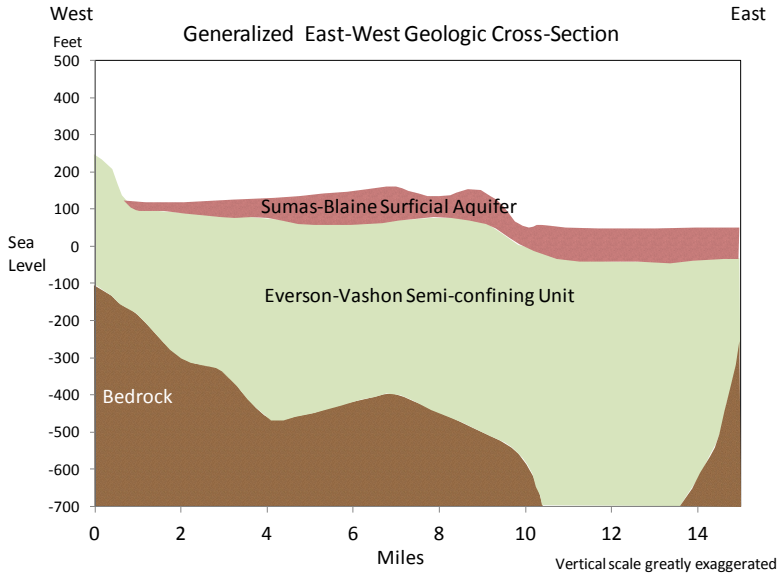
- Unconfined
- Thin
- Shallow depth to water
- Thick underlying semi-confining layer



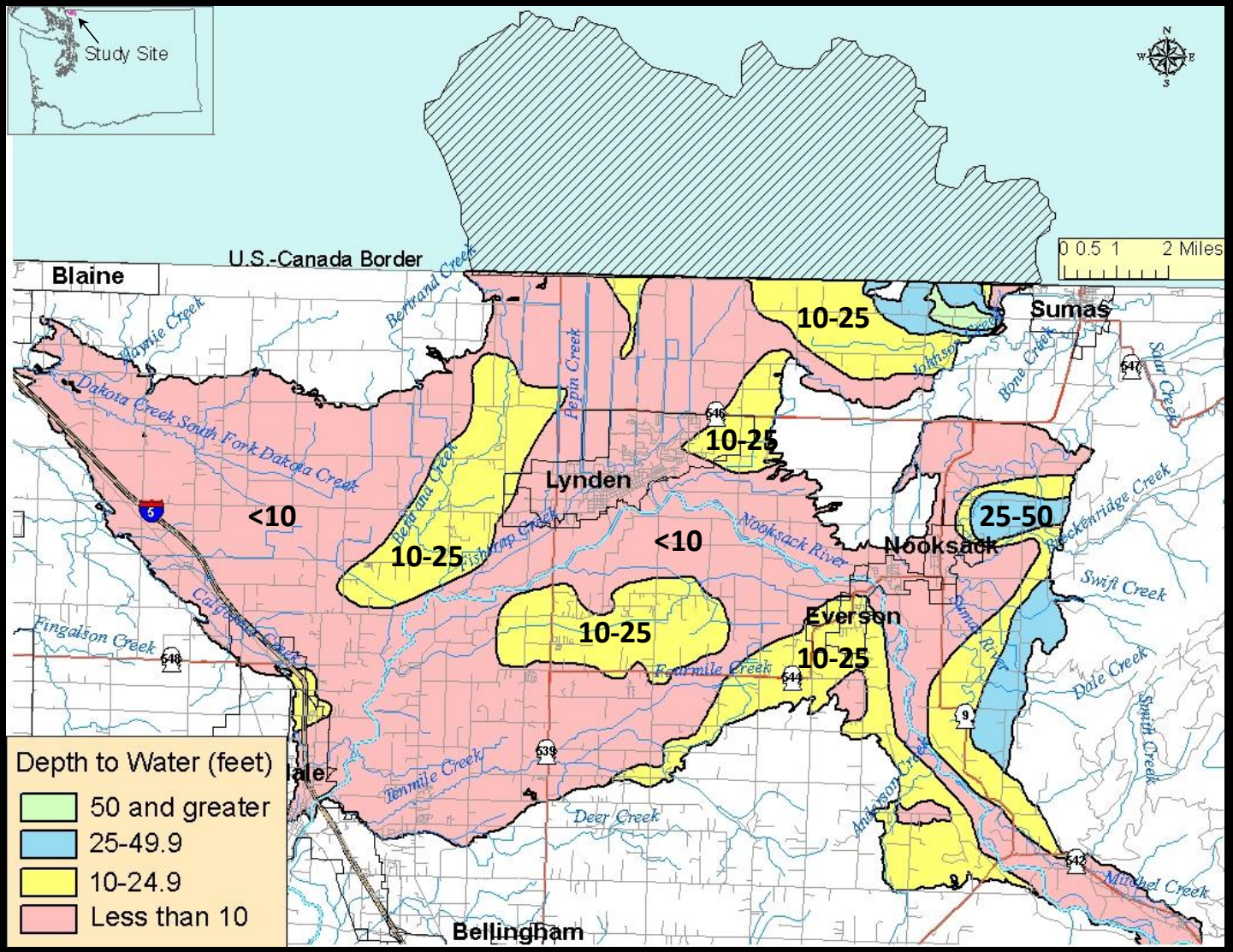
(Tooley and Erickson, 2006)

THIN aquifer(less than 50 feet thick mostly)—<u>and</u> the only major drinking water source for rural residents. Thick underlying fine-grained layer: not reliable water, poor quality.

Unconfined—no lower permeability layer to prevent contamination



(Cox and Kahle, 1999)

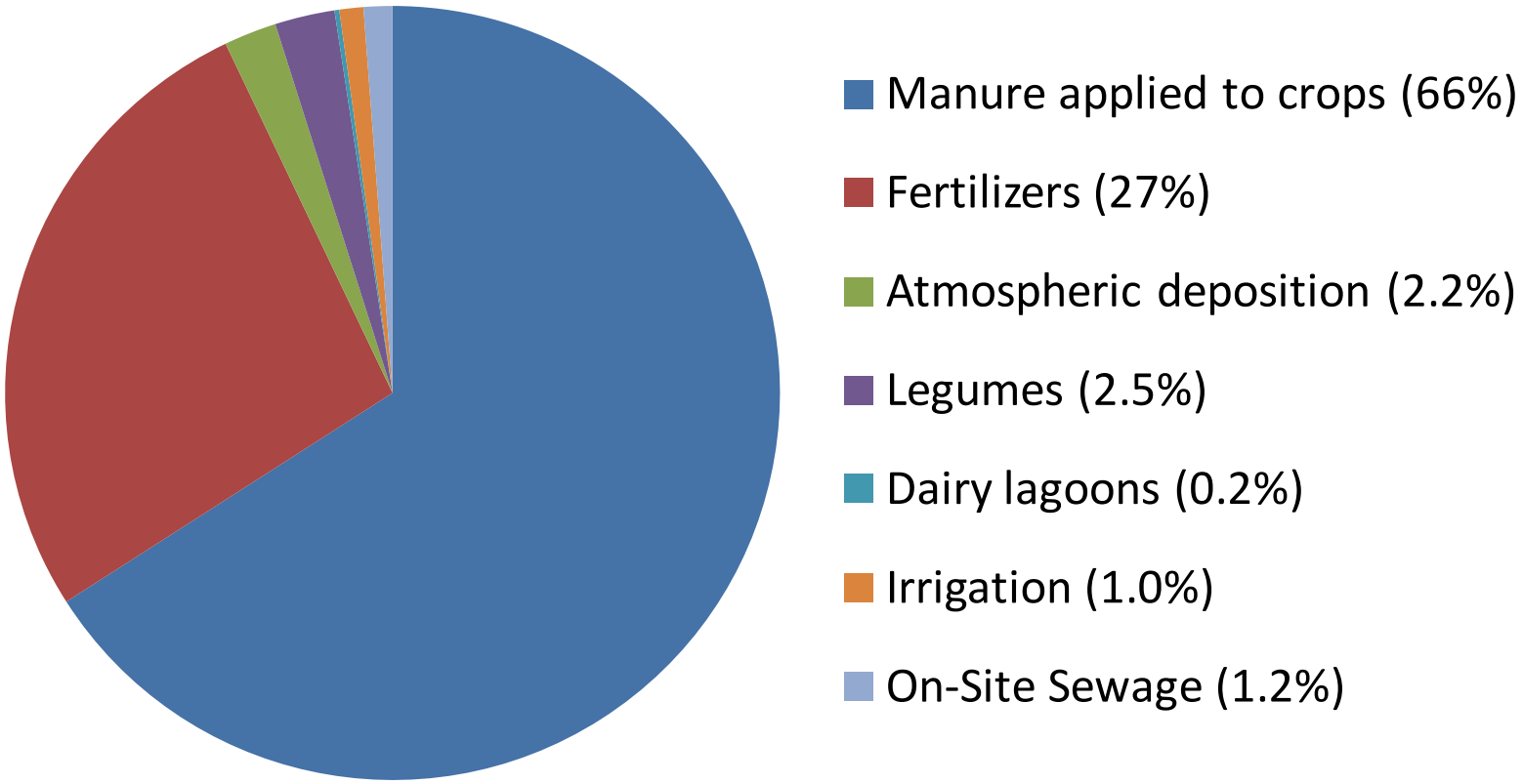


Shallow depth to water—less than 10 feet in most areas

(Tooley and Erickson, 2006)

What are the sources of nitrate?

Nitrogen **Inputs** to Land Surface Overlying the Aquifer



~16 million lb N/year total--~97% Agriculture

(from WA Dept of Agriculture,2010; Almasri, et al, 2003)

Nitrogen Loading to Ground—Main Sources

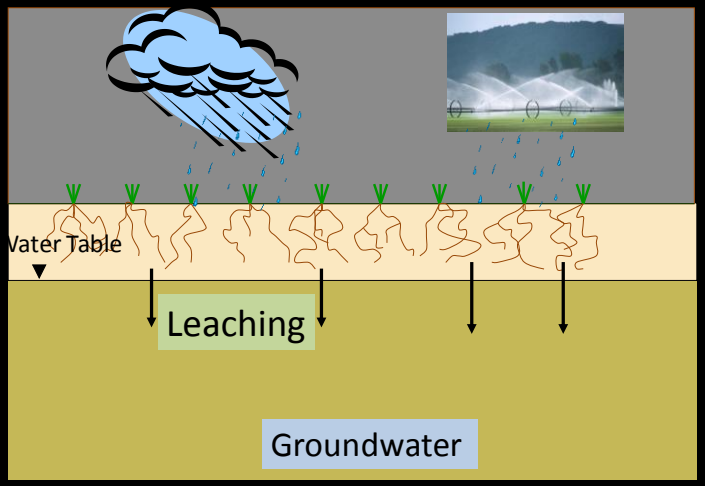
- Manure Application: 10-12 million lb/year (2010) (equivalent to a city of over 1 million people)

- Inorganic Fertilizer: 4.6 million lb/year (2003)

- Total of all sources: 15-17 million lb/year

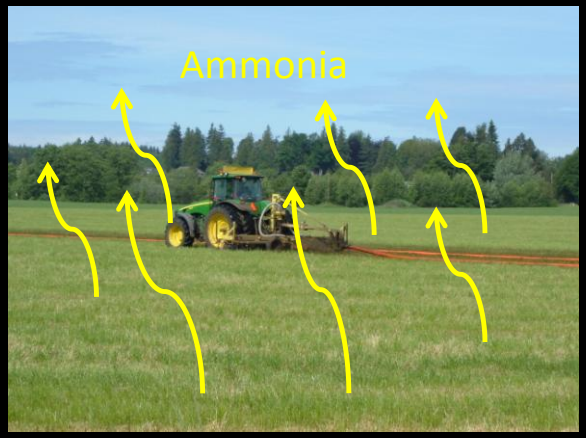
Nutrient Balance

1)Inputs = Outputs
2) Output = Crop Uptake + Losses



Main N Losses

- Leaching below the root zone
- Ammonia volatilization (manure)
- Runoff



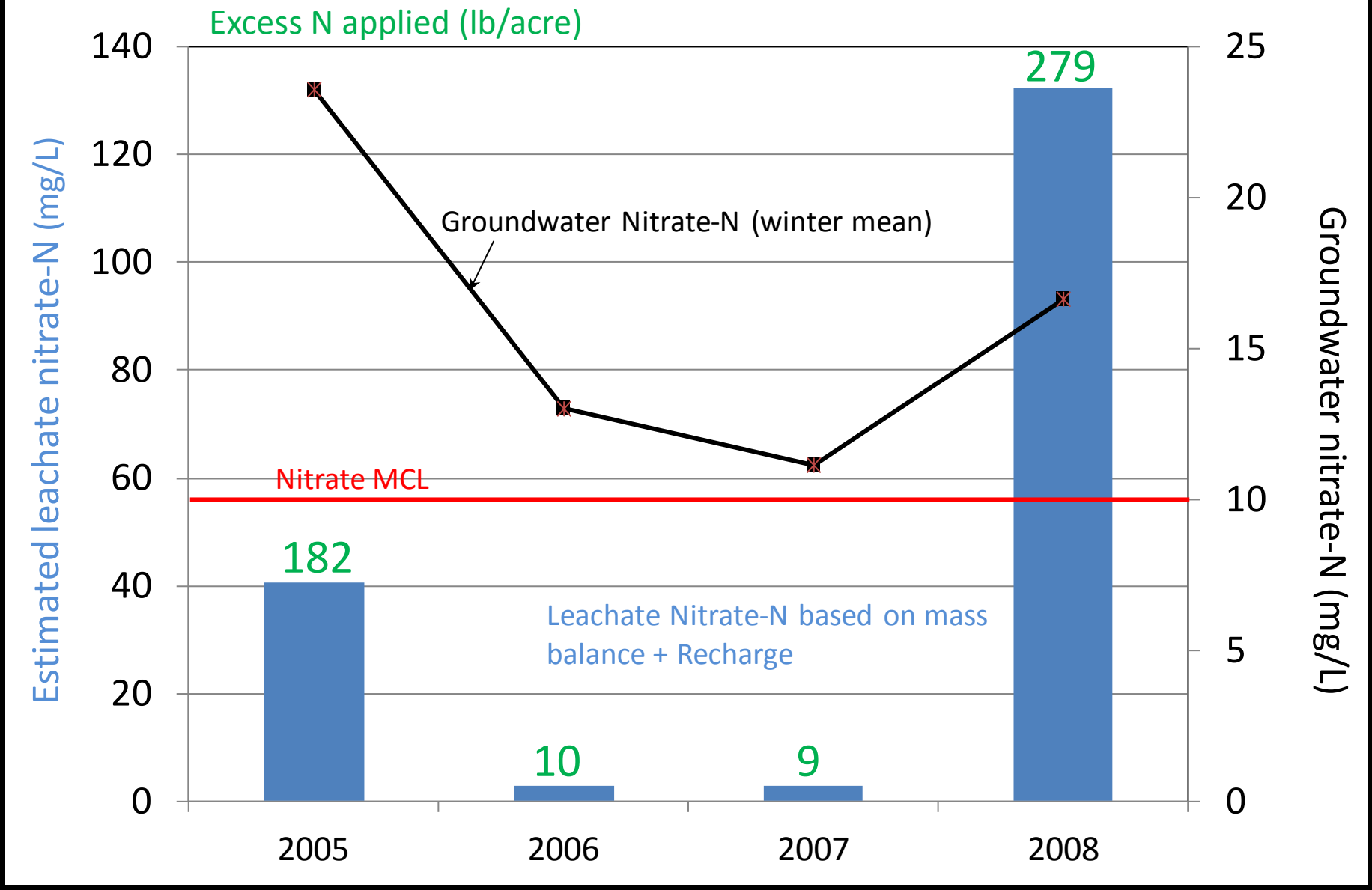
Issues affecting nitrogen uptake

- Crops
  - Grass and corn (dairies)
  - Berries

- N uptake and losses affected by
  - Amount of N applied (loading)
  - Timing of N application

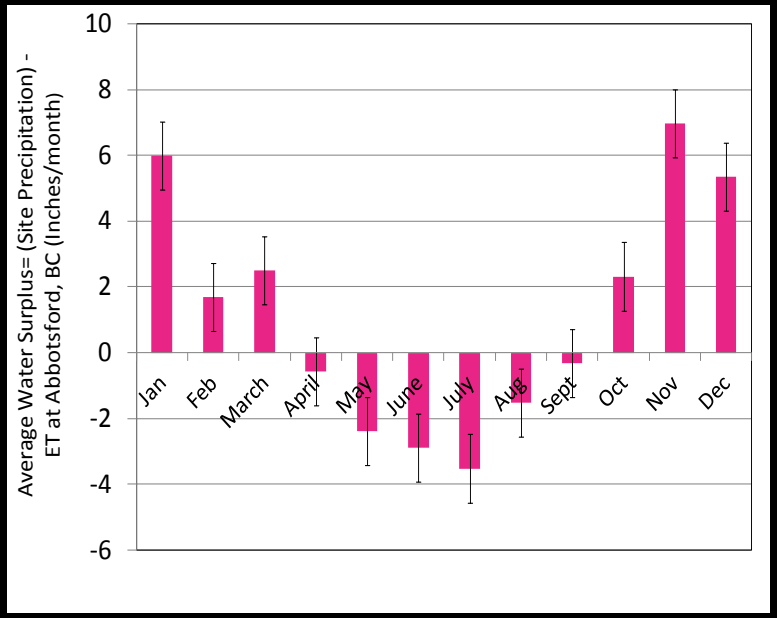
N mass balance study

- 20-acre grass field over the SBA—typical manure management
- EAP/WSU cooperative study, 4 years
- Quantified ~ALL manure, fertilizer, crop uptake, irrigation water nitrogen applied
- Tracked groundwater and soil nitrogen
- What happens when in balance (2 years) and when not in balance (2 years)?


Excess N applied (lb/acre)
Estimated leachate nitrate-N (mg/L)
Groundwater nitrate-N (mg/L)
140
120
100
80
60
40
20
0
25
20
15
10
5
0
279
182
10
9
Groundwater Nitrate-N (winter mean)
Nitrate MCL
Leachate Nitrate-N based on mass balance + Recharge
2005
2006
2007
2008

Timing: Applying manure or fertilizer during months when surplus of water, high risk of leaching to groundwater and/or runoff.

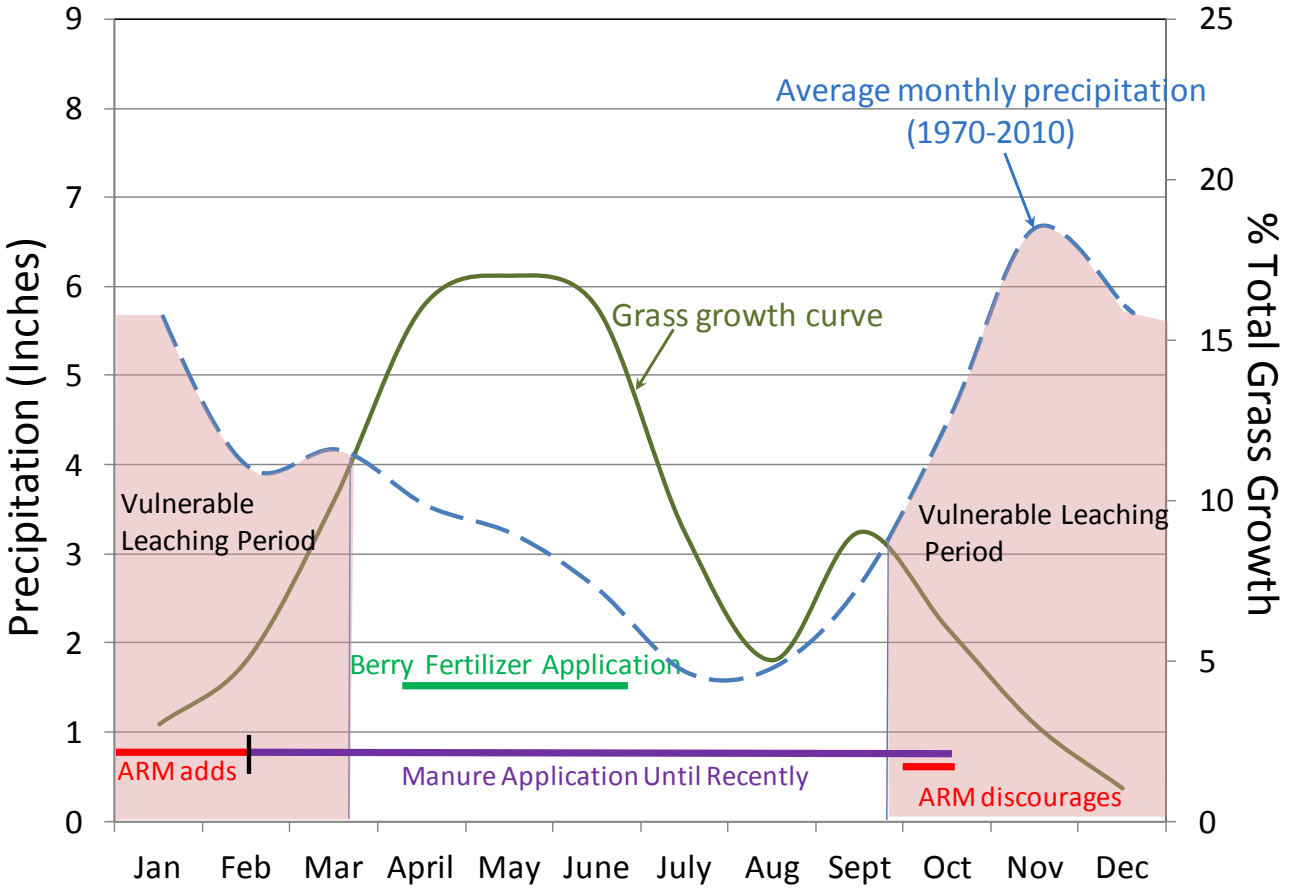
Water Surplus



Vulnerable Times for Leaching:

- Before mid-March
- After mid-September

Whatcom CD experimenting with "year-round" manure application at several dairies (ARM)



Current practice for manure application includes some vulnerable leaching periods. ARM extends further into vulnerable period (Jan-Feb) but discourages October application.

Application Risk Management (ARM)

- EPA grant to Whatcom CD (National Estuarine Program) to implement ARM System (~$700,000)
  - Year-round manure application
  - Total loading to the field not clearly accounted for
  - EPA added USGS groundwater monitoring ($800,000)
  - CD advocates ARM for all dairies in the state

New method extends manure application into vulnerable leaching period. Whatcom CD encouraging use statewide.

Raspberries and Irrigation Leaching Risk

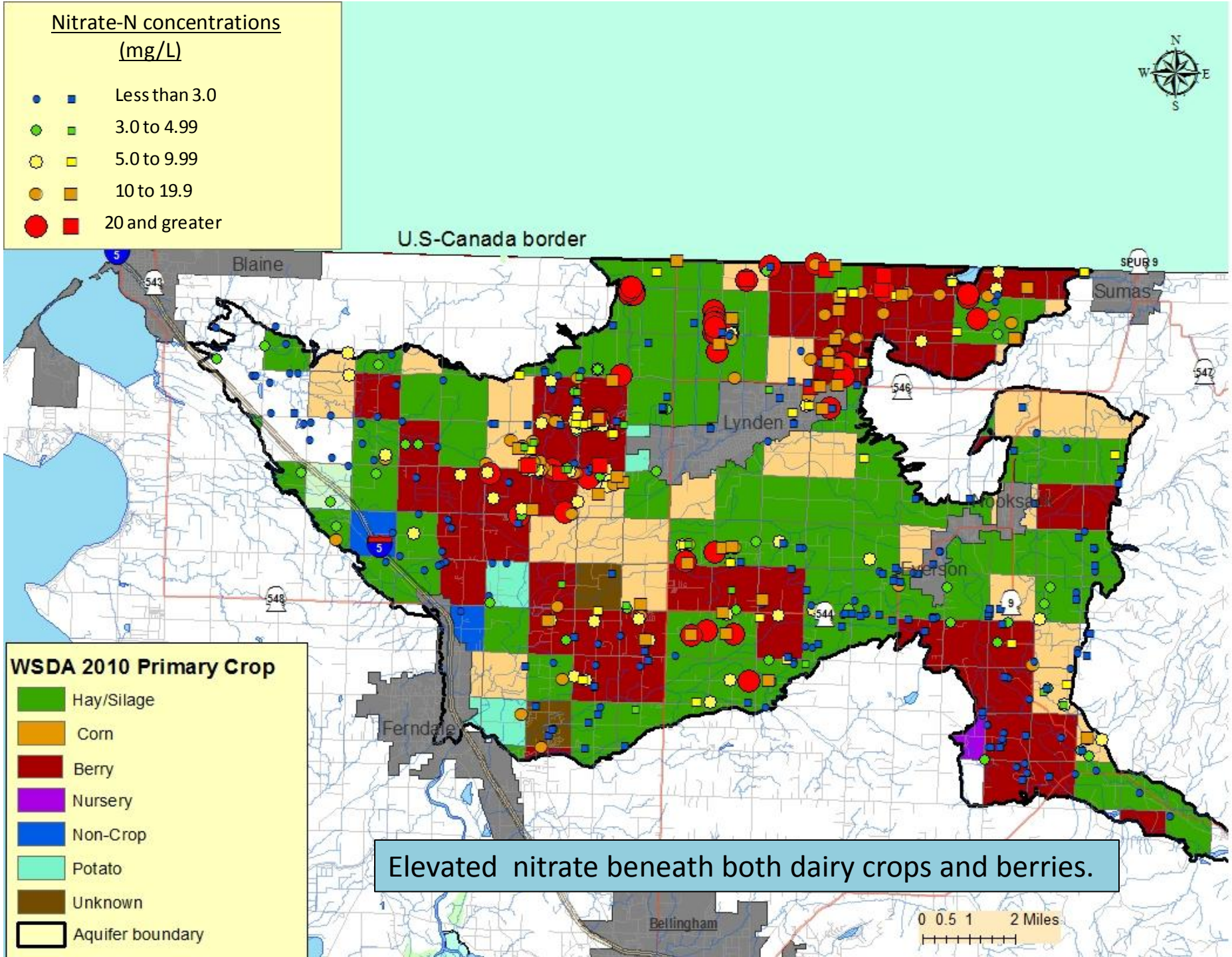
U. Of Calgary and Agriculture-Agri-Food Research Institute studies found:

- Up to 100% of fertilizer leached in newly renovated fields (Ryan and Loo, 2012)
- Berries take up very little N

GW and soil pore-water indicated leaching :

- 55 lb/acre April-May alone
- Another 50 lb/acre+ in fall
- Half as much N and water leached when irrigation based on evapotranspiration and crop need

Nitrate probably leaching from berry fields even though applying fertilizer only in growing season.


Nitrate-N concentrations (mg/L)
Less than 3.0
3.0 to 4.99
5.0 to 9.99
10 to 19.9
20 and greater
U.S-Canada border
Blaine
Sumas
Lynden
Everson
Ferndale
Bellingham
WSDA 2010 Primary Crop
Hay/Silage
Corn
Berry
Nursery
Non-Crop
Potato
Unknown
Aquifer boundary
0 0.5 1 2 Miles
Elevated nitrate beneath both dairy crops and berries.

Lower Yakima Shallow Aquifer Vulnerability

- Unconfined
- Shallow depth to water
- (Thicker than Sumas-Blaine Aquifer)

Comparison of Sumas-Blaine Aquifer to Yakima Nitrate Study area (US EPA, 2012)

Column1	Whatcom County	Yakima County
Number of people on private wells (over study areas)	18,000 to 27,000	24,000
Percentage of wells sampled exceeding 10 mg/L-N	29	21
Number of dairies in the county	124	68
Average total acreage/dairy[1]	69	466
Number of mature cows in the county 2010[1]	46,588	93,826
N loading from manure (lb/year/county)[2]	11 million	22 million
Manure N applied not including transported off site (lb/acr	291	1,066
N loading from synthetic fertilizer (lb/year)	4.6 million[3]	22 million[4]
Acres in agriculture (all types of ag)--2007[5]	73,700	344,500
Estimated average N loading from all sources (lb/acre)	**212**	**128**

[1] WA Dept of Agriculture data for dairies.

[2] WA Dept of Agriculture assumption of 35% loss of N in production, before application.

[3] Almasri et al, 2003

[4] Estimate based on comparison of $ spent on fertilizer and lb of N in Alsmasri et al, 2003 above.

[5] USDA 2007 National Agricultural Statistics, County Summary

Estimated total N loading rate from manure and inorganic N in Whatcom County is almost double that in Yakima. GW evidence that there's too much applied in both places.

Conclusions

- Nitrate concentration > 10 mg/L in nearly 1/3 of wells sampled 1981-2010 in the SBA
- Contamination widespread and consistent over time with current practices
- No easy replacement of SBA for drinking water
- 4-year field study showed that shallow GW nitrate higher when more N applied than crop takes up

Conclusions (cont)

- ARM System that extends N application into vulnerable leaching period risks additional leaching to GW
  - CD encouraging ARM use statewide
- Both SBA and Lower Yakima vulnerable to overapplication of N
- Health effects for 1000's of people on private and public wells in both areas

Recommendations

- In partnership with Dept of Health, keep rural residents informed about nitrate conditions and health risks of high nitrate in drinking water.
- Priority: minimize nitrate leaching for agriculture all over the state, especially over vulnerable aquifers.
  - ❖Ensure that dairies and other agricultural entities apply manure and fertilizer at appropriate times and amounts to stop contaminating GW
  - ❖Evaluate ARM effects on GW and surface water before expanding statewide

Acknowledgements

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- EAP Groundwater Group, WA State Department of Ecology

Main reference: Carey, B. and R. Cummings, 2012. Sumas-Blaine Aquifer nitrate contamination summary. WA State Department of Ecology, Olympia, WA, Publication No. 12-03-026., 55 p. https://fortress.wa.gov/ecy/publications/summarypages/1203026.html

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